ENERGY PRODUCING SYSTEMS

SOLAR POWER

INTRODUCTION

Energy from the sun falls on our planet on a daily basis. The warmth of the sun creates conditions on earth conducive to life. The weather patterns that occur on the earth are driven by the sun's energy. Step outside on a sunny day and one is instantly aware of the power of the sun. Spend too much time out in the sun and this energy can actually burn your skin as effectively as an open flame! The sun drives the process of photosynthesis that all plants depend on. The sun is essentially an inexhaustible supply of energy. It is a gigantic continuous nuclear reaction that has been on going for the last 5 billion years. Humans have recently developed technology to directly tap the sun's energy, although, in many ways we have been using the sun's energy all along. The energy we get from our food is derived directly or indirectly from plants and most life forms on this planet owes their existence to the sun.

Image Source: NREL

Solar energy technologies have significantly improved over the last 20 years. These systems are more efficient, reliable and less expensive. Solar energy systems do not produce air or water pollution during operation, can be applied in remote locations and are a renewable source of energy. Some solar energy systems convert the sun's radiant energy to electrical power that can be used for heating and cooling and even have applications in our transportation systems. As our need for energy increases and our ability to use fossil fuels decreases, solar energy will provide a viable option to meet our future energy needs.

TYPES OF SOLAR ENERGY SYSTEMS

Source: B. McConnell; NREL

PHOTOVOLTAIC

Photovoltaic (PV) cells are designed to generate electrical power directly from sunlight. PV systems have no moving parts, require very little maintenance, do not produce pollution or consume water during operation. Modern PV systems can covert up to 20 percent of the suns energy to electrical power. Most PV systems are made of a series of photo-cells constructed of thin layers of silicon. Sunlight is composed of light energy in the form of *photons*. When these photons strike the silicon layers of a photo-cell it “bumps free” electrons generating an electrical current. Photovoltaic systems can be easily expanded to generate the amount of electricity required for a given application and can be specifically tailored by adding or removing photo-cells. Small PV systems can be used to power stop lights, streetlights (see side picture) or small water pumps in remote locations. Solar arrays can be used to provide larger electrical needs such as for a school building or residential home. These systems can use batteries to store the electricity generated during the day providing power for nighttime electrical needs or when cloud cover reduces total sunlight. Quite often these systems use a “net metering” approach which allows the electric meter to turn backwards when excess power is being generated. Small photovoltaic systems are already in widespread use in calculators and other small electronic devices.

SOLAR-THERMAL

These systems are designed to concentrate the sun’s energy and convert it to thermal energy (heat). Examples can be as simple as a roof mounted hot water tank painted black to absorb sunlight or as sophisticated as an entire system of parabolic mirrors generating heat to produce steam from water.

The most common use of solar-thermal technology is in domestic water heating. Hot water heating is often the second leading home energy expense. In general these systems use a network of liquid filled tubes painted black to absorb sunlight and contain either water or an appropriate thermally conductive liquid (typically ethylene glycol) to carry the captured heat to its application. This approach can also be modified to meet residential space heating needs by storing the hot water generated during the day in tanks or a plumbing network located inside the home. This type of system is designed to release heat during the night. Heating of swimming pools is an excellent application for solar-thermal technology. These relatively simple systems are designed to heat the pool water during the day and use the thermal mass of the swimming pool to retain the heat during the night.

Advanced solar-thermal systems can be designed that utilize large grids of mirrors or lenses to concentrate the sun's energy. The captured solar energy is then used either to directly heat water to steam or to heat a carrier fluid (typically an oil) that is then circulated through a boiler to generate steam. The resulting steam can then be used to drive turbine systems to generate electricity or to provide mechanical power using a steam engine system. These systems have been successfully installed in California and currently generate electricity at a cost only slightly higher than conventional fossil fuels.

SOLAR BUILDING DESIGNS

One of the simplest ways to use the power of the sun is in building design. Most homes can be designed or modified to take advantage of sunlight. Half the energy used by an average residential home goes toward heating and cooling needs. Solar energy can be used to heat buildings by using south facing windows designed to let the sun's warmth in during the winter months. Thick foundations and walls are used to store the sun's thermal energy and release the heat during the night. During the summer roof overhangs, shutters, glazes and trees can be used to deflect solar heat helping to keep a building cooler. In areas with significant numbers of cloudy days, buildings can still use sunlight for passive lighting needs. Schools, industries and commercial businesses that are occupied mainly during daylight hours can especially benefit from passive solar lighting and heating. Passive solar lighting can be a major consideration in commercial and industrial buildings where over 30 percent of the energy is consumed for lighting needs.

Souce: L rawlings, NREL

Tests conducted by the National Renewable Energy Laboratory indicate that passive solar designs use 47 percent less energy than conventional new buildings and 60 percent less energy than older buildings. In most cases passive solar homes are no more expensive to construct than traditional designs. Such homes often offer a more open and pleasing floor plan, reduced indoor air pollution and significantly reduced energy consumption.

WHERE ARE SOLAR SYSTEMS APPLICABLE?

Passive solar lighting is applicable in any location in the world and can significantly reduce the energy required for daytime lighting. Worldwide more than 2 billion people still do not have direct access to electricity. The cost of connecting remote or rural areas to the standard electric grid system is often far more expensive than installing solar systems. A significant advantage of solar power is the ability to provide stand-alone power for local applications. The number of sunny days available can be a factor for practical application of photovoltaic and solar-thermal systems. The actual amount of sunlight required depends on each specific solar application. The attached maps indicate the solar radiation received in various parts of the United States. The brightest opportunities for solar power exist in the sunbelt states of Arizona, Nevada, New Mexico and parts of Texas and Southern California.

Solar opportunities are also available throughout the Midwest and Mountain states. In these locations passive solar building designs are especially useful and can significantly reduce energy costs associated with heating and lighting.

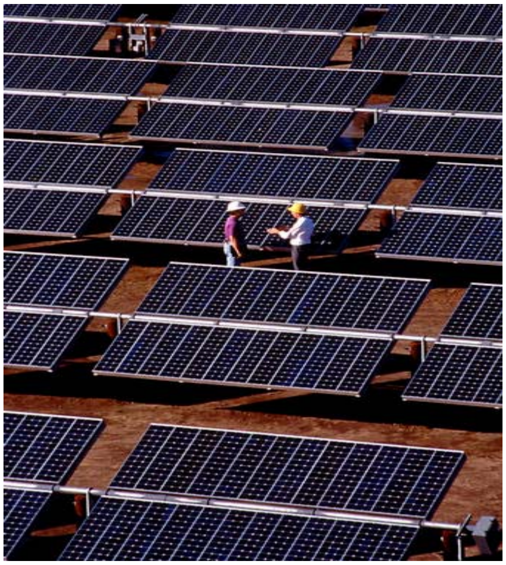
SPECIFIC CHARACTERISTICS OF SOLAR POWER

Solar power is widely available over most of the earth representing a consistent and renewable source of energy. For all practical purposes we will never run out of sunlight. There are a variety of solar systems from passive solar heating designs to using solar power to generate electrical power. Most solar power systems can be easily sized to fit the application. Small photovoltaic units can provide power to a single traffic light or be scaled up to create large photovoltaic grids providing power to thousands of homes. Solar power is a clean source of energy and operates without the air and water pollution issues associated with burning fossil fuels.

Seasonal variations and occasional cloudy days can affect the availability of solar energy. Independent residential photovoltaic solar systems often use a system of batteries to store electrical power generated during the day, for use at night or in the event of persistent cloudy days. Large utility-level solar applications can solve the intermittent characteristics of solar power by using hydro-storage (*pumped storage*) systems. In these cases electricity generated during the day is used to pump water up hill into a large reservoir. The reservoir is then used as a conventional source of hydroelectric power during the night or during periods of cloudy weather. Solar power can also be used to “split water” in order to generate hydrogen gas. Electricity derived from solar power is used to break the bonds of water molecules releasing hydrogen, which is a fuel source that can be stored and distributed in a manner similar to existing systems for natural gas.

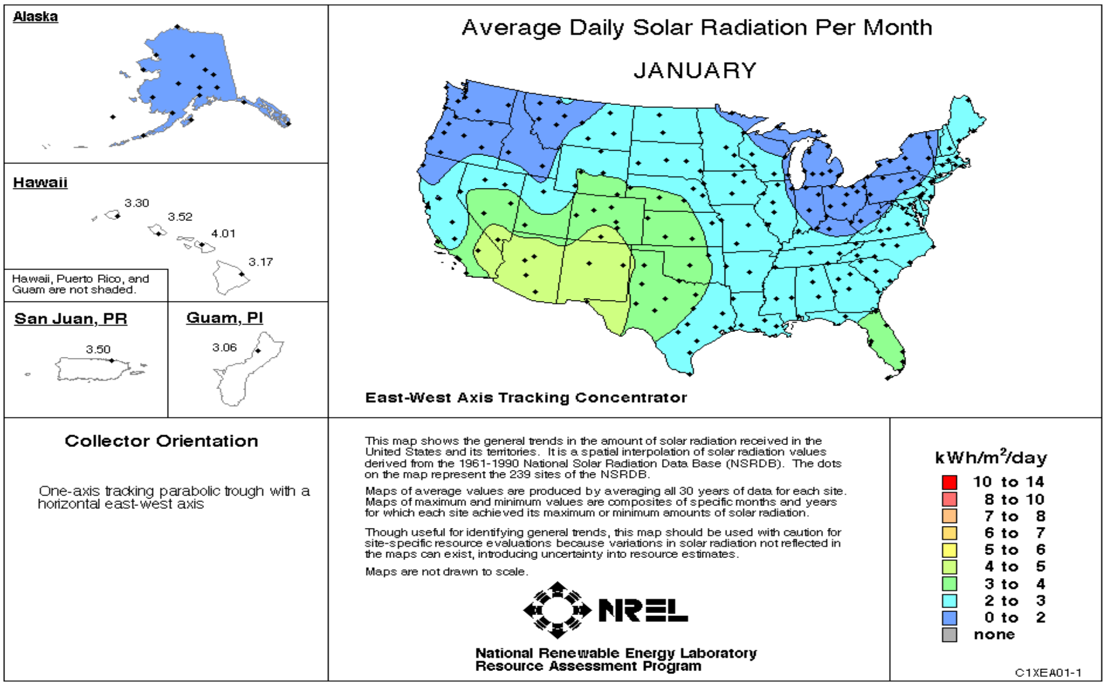
While early solar panels installed on the roofs of buildings tended to have a large visual impact, new solar panel designs have been incorporated into roof shingles. This system looks similar to the roof of a home using a conventional power system. The cost of capturing solar energy has dropped dramatically over the last 20 years. Solar energy is becoming competitive with other nonrenewable energy systems currently used to generate electrical power, such as coal or natural gas. Currently, over 200,000 homes worldwide depend on photovoltaic solar systems to provide all of their electricity.

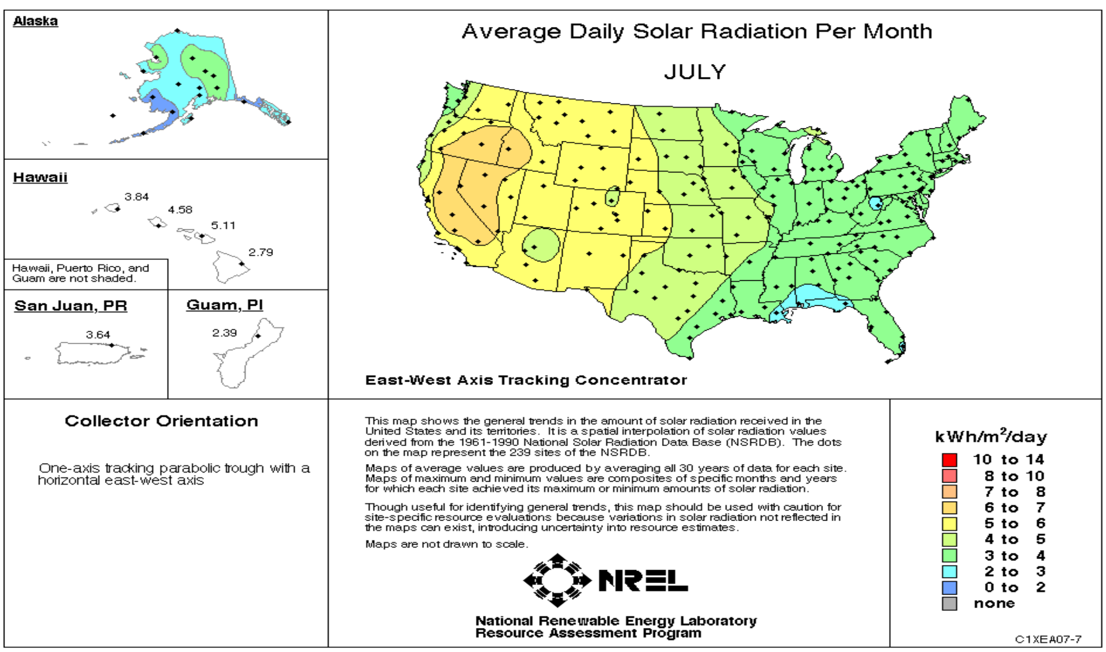
THE FUTURE OF SOLAR POWER IN MISSOURI



In the last seven years worldwide sales of photovoltaic solar systems have tripled. Use of a photovoltaic system that generates 150 kWh per month will prevent 150 pounds of coal from being mined and prevent 300 pounds of carbon dioxide from being produced each month. A variety of solar power applications are viable here in Missouri. Photovoltaic systems currently are used all across the state to pump water in remote locations, provide power for traffic lights, provide power for telecommunication towers and provide supplemental residential power. Solar thermal water heaters greatly reduce the energy needed to provide hot water. Missouri is also an ideal state for passive solar building designs. Many solar systems pay for themselves in energy savings in just a few years.

Missouri currently derives 84 percent of its electrical needs from burning coal. Through the use of passive solar home designs, photovoltaic systems and solar thermal hot water heating systems a modern Missouri home could radically reduce its reliance on fossil fuels. The use of solar power systems and designs could not only help Missouri reduce the flow out of state of dollars spent on energy, but would reduce the pollution associated with current levels of fossil fuel use.


Alaska
Hawaii
3.30
3.52
4.01
3.17
Hawaii, Puerto Rico, and Guam are not shaded.
San Juan, PR
3.50
Guam, PI
3.06
Average Daily Solar Radiation Per Month
JANUARY
East-West Axis Tracking Concentrator
Collector Orientation
One-axis tracking parabolic trough with a horizontal east-west axis
This map shows the general trends in the amount of solar radiation received in the United States and its territories. It is a spatial interpolation of solar radiation values derived from the 1961-1990 National Solar Radiation Data Base (NSRDB). The dots on the map represent the 239 sites of the NSRDB.
Maps of average values are produced by averaging all 30 years of data for each site. Maps of maximum and minimum values are composites of specific months and years for which each site achieved its maximum or minimum amounts of solar radiation.
Though useful for identifying general trends, this map should be used with caution for site-specific resource evaluations because variations in solar radiation not reflected in the maps can exist, introducing uncertainty into resource estimates.
Maps are not drawn to scale.
NREL
National Renewable Energy Laboratory
Resource Assessment Program
kWh/m²/day
10 to 14
8 to 10
7 to 8
6 to 7
5 to 6
4 to 5
3 to 4
2 to 3
0 to 2
none
C1XEA01-1


Alaska
Hawaii
3.84
4.58
5.11
2.79
Hawaii, Puerto Rico, and Guam are not shaded.
San Juan, PR
3.64
Guam, PI
2.39
Average Daily Solar Radiation Per Month
JULY
East-West Axis Tracking Concentrator
Collector Orientation
One-axis tracking parabolic trough with a horizontal east-west axis
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NREL
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kWh/m²/day
10 to 14
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6 to 7
5 to 6
4 to 5
3 to 4
2 to 3
0 to 2
none
C1XEA07-7